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SMALL MAMMAL SURVEYS ON LITTLE BIGHORN BATTLEFIELD NATIONAL MONUMENT

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SMALL MAMMAL SURVEYS ON LITTLE BIGHORN BATTLEFIELD NATIONAL MONUMENT

Final Report

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by

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Northern grasshopper mouse feeding on a grasshopper (photo by Milo Burcham).

Introduction

The current report provides the results of a small mammal survey conducted on Little Bighorn Battlefield National Monument (LBB) in the summers of 2002 and 2003. The primary objective of this study was to survey the small mammals of LBB in an effort to achieve a 90% inventory of the small mammal communities there. Given the potentially high species richness and the potential rarity of some prospective community members, we conducted intensive sampling throughout LBB using a range of trapping techniques to ensure that the suite of traps provided the most effective means of sampling the entire small mammal community. Additionally, the use of snap traps and pitfalls provided voucher specimens for identification purposes. Since at least one fourth of the species potentially present are difficult to impossible to conclusively identify without using dental, skull, or baculum characteristics (e.g. nearly all the shrews, several voles, and some chipmunks and mice), examination of these characteristics were necessary to approach the 90% census goal and establish conclusive species identifications. A secondary objective of this study was to evaluate small mammal habitat use in the context of exotic plant invasions occurring within the park.

Methods

We developed a prospective species list (Table 1) for LBB by examining small mammal distribution records for Big Horn County (Foresman 2001a) to provide a starting point for developing our survey. We developed this prospective species list in the context of the habitat associations known for these animals given the habitats present on LBB. However, the list was intended to be overly inclusive to ensure we did not overlook any potential species we might encounter in developing survey protocols. Based on this list, and the knowledge that many traps have inherent biases in their ability to detect different species (Martel 1979, Innes and Bendell 1988, Allen et al. 1997), we developed an intensive survey employing a range of trap types that included: Sherman live traps (7.6 x 8.9 x 22.9 cm), number 202 Tomahawk live traps (47 x 15 x 15 cm), pitfall traps (large coffee cans 50 cm diam by 17 cm tall), Museum Special snap traps, standard small snap traps, and gopher traps. After an initial visual walk-through and survey of the different habitats on LBB, we developed a protocol to maximize the coverage of different habitats by deploying the various trap types along transects and at spot trapping locations throughout the park. Specific traps were deployed over different distributions and time frames as described below, but overall approximately 3 weeks of sampling occurred in August each year. The entire sampling effort was replicated for two years to account for the notable variability associated with small mammal populations (Krebs 1996) that can result in very low densities of a range of species during any single year. The beginning and end points of each transect were recorded using a global positioning system (GPS: see Appendix 1).

Live Trap Sampling

Live trapping was conducted by setting out traps along transects (Pearson and Ruggiero 2003) spaced at 10-m intervals. Live traps were run for four day intervals on each transect before shifting them to new locations. Traps were baited with peanut butter and oats, and checked each morning. Live-trapped animals were identified to species, weighed, ear tagged (#1005 finglerling ear tags), and their sex, age, and reproductive

condition was determined before being released at the trap station (Pearson et al. 2001). Tomahawk traps were strategically placed near burrow entrances, shrubby habitats, and rocky outcrops to target larger small mammals like ground squirrels, chipmunks, and wood rats based on habitat associations for these species (Pearson 1999, Foresman 2001a). Visual and audio surveys were conducted in appropriate habitats for marmots and tree squirrels. The visual and audio surveys were not standardized.

Snap Trap and Pitfall Sampling

Snap traps were set out along transects at 10 m spacing and run for three days per week. Traps were baited with peanut butter and checked each morning. After three days, snap traps were rotated to new locations. Pitfall traps were set into the ground so the tops were level with the ground surface, and they were baited with peanut butter and partially filled with water. Pitfall locations were coordinated with the chief ranger of LBB to ensure sensitive areas were not disturbed, and a park ranger accompanied and supervised pitfall digging to ensure no artifacts were disturbed or removed from the park. Pitfalls were checked once each day and run for approximately 10 days. Gopher traps were used to target pocket gopher tunnels. Captured animals were processed as described above for live trapping and were then bagged and placed on ice until they could be frozen. A subset of specimen skulls and or skins were prepared (see below) and retained for voucher specimens, which were submitted to LBB (Appendix 2). The remaining materials were discarded.

Vegetation Sampling

Trapping effort was stratified to cover the full range of vegetation types available. Cover estimates of habitat variables such as bare ground, rock, litter and dominant species of native and nonnative vegetation were made by visually estimating the percent cover of each species within a 3-m radius of the trap station on live trap transects (after Pearson et al. 2000, 2001). Vegetation along the snap trap transects and at other trapping locations was simply assigned to a dominant vegetation type for all the unique vegetation zones along transects.

Specimen Identifications and Specimen Collections

Specimen collections focus on smaller taxa, particularly those that are difficult to identify. Specimens were identified by D. E. Pearson and independently confirmed by K. R. Foresman using Hoffman and Pattee (1968) and Foresman (2001b). We attempted to prepare a voucher collection comprised of one or two specimens of each species whenever damage by traps or heat did not destroy specimens. All standard museum measurements including the total length of the specimen from the tip of the nose to the end of the tail, tail length, right ear and left hind foot length, testes length in males and the number of placental scars in females were made prior to preparation of specimens (Hall 1962), and a complete database of this information reside at the USDA Forest Service, Rocky Mountain Research Station in Missoula, Montana.

Analytical Methods

Species effort curves were constructed from the survey data to provide some measure of the degree of success in achieving the 90% census goal. Species effort curves

were constructed by graphing the cumulative number of species against the cumulative sampling effort, where sampling effort was broken into six 1-week periods comprising three weeks of trapping in 2002 and three weeks of trapping in 2003. These curves should reach an asymptote and level out if additional effort is generating relatively few new species (Palmer 1990).

Logistic regression was used in the context of resource selection function analysis (Manly et al. 1993) to determine significant variables separating trap stations capturing animals from those not capturing animals. This was done for each year separately where sufficient data was available for separate analyses. Trap stations were only used once, i.e., multiple captures at a station result in that station being classified as a capture station. Analyses were conducted only for live trapping stations because these are the only places where intensive vegetation data were gathered and analyses were conducted only for those species having sufficient captures to effectively evaluate habitat use. Habitat variables were lumped into exotic grass, native grass, exotic forb, native forb, shrub, bare ground, and poison ivy (*Toxicodendron radicans*). The primary focus was on exotic versus native vegetation for the primary plant functional groups of grasses and forbs. Shrubs and bare ground were included because these have previously been shown to represent important habitat variables for mice (Pearson et al. 2001). Poison ivy was included because it served as an indicator species for the moister riparian habitat near the river versus the xeric upland habitat.

Results

Total trapping effort at LBB each year was approximately 1180 trap nights (1 trap night = 1 24-hr period per trap) for live traps, 2280 trap nights for Museum Special snap traps, 75 trap nights for pitfalls, and approximately 220 trap nights for Tomahawks, standard snap traps and gopher traps. Tomahawks, standard snap traps, and gopher traps were used to target specific species based on habitat and reconnaissance information. This total sampling effort approximated > 3750 trap nights along > 11 km of transects at > 45 locations (transects and spot trapping sites) in each year (Fig. 1). Voucher specimens prepared and transferred to LBB are listed in Appendix 2.

In 2002, trapping resulted in 300 captures of 296 individual small mammals. At least nine species of small mammal were identified (Table 2): deer mouse (*Peromyscus maniculatus*), white-footed mouse (*Peromyscus leucopus*), western harvest mouse (*Reithrodontomys megalotus*), bushy-tailed woodrat (*Neotoma cinerea*), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), northern pocket gopher (*Thomomys talpoides*), cottontail (believed to be mountain cottontail [*Sylvilagus nuttallii*]), yellow-pine chipmunk (*Tamias amoenus:* identification based on pelage), and prairie vole (*Microtus ochragaster*). One tiger salamander (*Ambystoma tigrinum)* was live-trapped in a pitfall and released, and several western meadowlarks (*Sturnella neglecta*) were captured in live traps and released. In addition to trapping, visual observations were also made (Table 3) of white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemonius*), cottontails (most likely *Sylvaligus nuttalli*), raccoons (*Procyon lotor*), coyotes (*Canis latrans*), antelope (*Antilocapra americana*), a snapping turtle (*Chelydra serpentina*), an eastern racer (*Coluber constictor*), western rattlesnakes (*Crotalus viridis*), and a greater short-horned lizard (*Phrynosoma hernandesi*).

In 2003 the same trapping effort was repeated over the same areas, producing 143 captures of 132 individual small mammals. At least 10 species of small mammal were identified (Table 2) including: deer mice, white-footed mice, western harvest mice, northern grasshopper mice (*Onychomys leucogaster*), thirteen-lined ground squirrels, a yellow-pine chipmunk, a cottontail, meadow jumping mice (*Zapus hudsonius*), prairie voles, and a Merriam's shrew (*Sorex merriami*). Three tiger salamanders were also captured - one in a snap trap and two in pitfalls. The two in pitfalls were released live. Three of these species, the Merriam's shrew, northern grasshopper mice, and jumping mice, were new additions to the LBB species list. In addition, visual observations were also made of eastern racers, western rattlesnakes, snapping turtles, and red foxes (*Vulpes vulpes*). Red foxes had not been seen the previous year. Locations are given in Fig. 2 for uncommon and rare species.

The species effort curve rose at a relatively steady rate over the course of the survey (Fig. 3). Although it slowed in the second year, we did add 3 species or 25% of the total list in the second year. Thus, it is not clear that the curve ever reaches an asymptote by the end of the survey.

Habitat associations could only be quantified for the two most common species, deer mice and white-footed mice, for which there were sufficient captures on the live trap transects for analyses. In 2002, deer mice tended to be captured at trap stations with lower shrub cover, higher cover of native grasses, lower cover of exotic grasses, lower cover of native forbs, and higher percentages of bare ground (Fig. 4). Backward stepwise logistic regression indicated that deer mice exhibited significant habitat selection in 2002 following stepwise reduction of the model to only variables ($\chi^2 = 11.46$, df = 2, $P = 0.003$). The variables remaining in the model indicated that deer mice tended to be captured at trap stations with lower shrub cover ($\beta = -0.028$, Wald = 2.981, df = 1, $P = 0.084$) and lower exotic grass cover ($\beta = -0.060$, Wald = 5.274, df = 1, $P = 0.022$) compared to stations were mice were not trapped. In 2003, patterns of habitat use by deer mice appeared quite similar to 2002, except that the strength of differences was generally weaker with fewer differences apparent between stations with and without captures (Fig. 3). Logistic regression analysis nonetheless suggested that significant selection was exhibited by mice after the model had been reduced to two variables ($\chi^2 = 10.34$, df = 2, $P = 0.006$). The variables remaining in the model indicated that mice were captured more at trap stations with higher cover of native forbs ($\beta = 0.026$, Wald = 4.364, df = 1, $P = 0.037$) and more bare ground ($\beta = 0.041$, Wald = 8.454, df = 1, $P = 0.004$) compared with stations where mice were never captured. The weaker selection patterns in 2003 were probably due largely to fewer captures in this year contributing to the differences in selection results between years. Given the high degree of similarity in the overall patterns of use between years, we pooled that data for the two different years and conducted an overall selection analysis. The stepwise logistic regression reduced the variable set to a significant model with three variables ($\chi^2 = 16.391$, df = 3, $P = 0.001$). The three variables contributing to this model indicated that overall mice selected for trap stations with higher native forb cover ($\beta = 0.024$, Wald = 4.493, df = 1, $P = 0.006$), more bare ground ($\beta = 0.033$, Wald = 7.590, df = 1, $P = 0.006$), and less exotic grass ($\beta = -0.019$, Wald = 4.302, df = 1, $P < 0.001$). The primary grass making up the exotic grass category was by far cheatgrass (*Bromus tectorum*).

White-footed mice were only captured once at live traps in 2003, so habitat use could only be evaluated for 2002 captures. In 2002, trap sites where white-footed mice were captured tended to differ from non capture sites for almost all variables (Fig. 5). However, the backwards stepwise regression resulted in only two variables being included in the final significant selection model ($\chi^2 = 38.68$, df = 2, $P < 0.001$). This model suggested that white-footed mice favored trap stations with higher cover for shrubs ($\beta = 0.048$, Wald = 15.10, df = 1, $P < 0.001$) and poison ivy ($\beta = 0.099$, Wald = 14.11, df = 1, $P < 0.001$). The shrub category was primarily snowberry (*Symphoricarpos* spp.).

Discussion

This two-year survey of small mammals on LBB resulted in approximately 168 observation days in the field and over 7500 trap nights that have significantly expanded the park species list by adding 11 new species of small mammals to the park inventory (Table 1, 2). Small mammal species diversity appears to be relatively high at LBB with 13 total species identified to date and most of these uncommon to quite rare. Deer mice clearly were the most abundant species followed by white-footed mice, which were abundant, and western harvest mice and prairie voles, which were both uncommon. The remaining species were relatively rare. This effort also identified 5 species of herpetofauna including two new reptiles and one new amphibian for the park.

Trapping in the first year identified nine species of small mammals, of which eight species were new to the park: the northern pocket gopher, prairie vole, bushy-tailed woodrat, white-footed mouse, deer mouse, western harvest mouse, yellow-pine chipmunk, and thirteen-lined ground squirrel. The yellow-pine chipmunk was the most difficult of these to identify. It is possible that this could be a least chipmunk, but based on pelage and habitat, we presume it to be a yellow-pine chipmunk. In the second year, in addition to recapturing most of the small mammal species trapped in 2002, trapping added three new small mammal species to the list: the Merriam's shrew, the northern grasshopper mouse and the meadow jumping mouse. The northern grasshopper mouse is a new county record for Bighorn County based on Foresman (2001a). Given the home range sizes of these species, it is reasonable to assume that all are breeding residents on LBB.

In addition to these target species, several nontarget species (non-small mammal species) were also identified (Table 3). Not surprisingly, all larger mammals observed were all known to be present in the park prior to this survey. However, several amphibians and reptiles were also observed, some of which were not previously recorded for LBB, based on prior LBB species lists. In fact, amphibian and reptile surveys conducted on LBB in 2001-2002 identified no herpetofauna within the park (Hossack et al. 2001, NPS annual research reports). However, these were brief visual surveys that involved only a few days of survey effort. The use of pitfalls on the small mammal survey and the massive amount of time spent in the field provided greater returns in terms of herpetofauna observations in this survey. Of the 19 species listed as plausible herpetofauna for LBB by Hossack et al. (2001), we documented 5 or 26%. Of these, the eastern racer was listed as present, and western rattlesnake was listed as probably present, but the tiger salamander, snapping turtle, and greater short-horned lizard were not listed for the park (NPS database for LBB obtained from David Pillmore). Since the snapping turtle was observed in the river, it is unclear to what extent this species actually occurs

within the park boundaries, but it is possible snapping turtles use the riparian areas along the Bighorn River within the park for nesting sites. Although, western rattlesnakes were only listed as probable, they presumably were known to be present in the park given that park brochures warn of rattlesnakes. Both reptiles and the amphibian we observed were previously known from Bighorn County (Maxell et al. 2003, Werner et al. 2004).

The species effort curve rose at a relatively steady rate over the course of the survey (Fig. 3) and did not ever clearly reach an asymptote by the end of 2003. After surveying the park and becoming more familiar with its habitats, some prospective species in Table 1 (which was intended to be overly inclusive) seem unlikely such as vagrant shrews, snowshoe hares, Columbian ground squirrels, black-tailed prairie dogs, northern flying squirrels, and Uinta chipmunks. However, this still leaves 35 species in Table 1, of which we sampled 12. Additionally, we did not observe red squirrels or porcupines, but these species are listed as present in the park database. Thus, our survey accounts for 35% of the potential species listed in Table 1, after subtracting the six unlikely species listed above. This percentage rises to 40% if we include the red squirrel and porcupine, which were already known from the park. Although Table 1 undoubtedly overestimates the likely true species list for LBB, it would be difficult to defensible reduce it greatly without excluding as possible some species which may actually occur within the park. This is in part because many of the species are rare shrews for which little is really known about their habitat associations and distributions and in part because the park occurs in an area which encompasses the range periphery for numerous species (Foresman 2001a). In short, the LBB area is a potentially rich location for small mammal species. We conclude that despite the intensive effort put forward during this survey, it undoubtedly has not resulted in a 90% census of LBB's small mammal species. Additional effort would surely add to the park list, though the returns are likely to slow down greatly at this point. Additional voles, shrews and various oddball species are likely to be added to this list over time.

Habitat associations could only be quantified for the two most abundant small mammals, deer mice and white-footed mice. In 2002, deer mouse habitat selection appeared to be driven by avoidance of shrubs and exotic grasses. In 2003, an affinity for sites with more bare ground and higher percent cover of native forbs appeared to determine deer mouse habitat selection. Despite these differences in the specific variables identified as significant between years, the overall patterns in selection were remarkably similar between years and this was reflected in the pooled analysis showing that, overall, deer mice selected for sites with more bare ground, higher percent cover of native forbs, and lower percent cover of exotic grasses. Previous studies of deer mouse habitat selection in western Montana grasslands have shown that deer mice tend to favor sites with more bare ground or less vegetative cover (Elliott et al. 1997, Pearson et al. 2001). In other studies deer mice have been shown to avoid native forbs (Pearson et al. 2001), but in this situation native forbs appeared to provide some unique attribute that contributed to the selection models for 2003 and for both years combined. Since the differences in native forb values between traps with and without mouse captures was minimal yet the variable was significant in the analysis, this suggests that native forbs in combination with other habitat variables were associated with unique conditions which were favorable to mice. The avoidance of exotic grass by deer mice is particularly interesting given the extensive invasion of exotic grasses at LBB. Deer mice are habitat

generalists very capable of responding to changing conditions (e.g., Pearson et al. 2000). If deer mice respond negatively to invasion of exotic grasses, then other less generalist species might be expected to as well. Cheatgrass was the dominant invasive exotic grass that we observed on LBB.

White-footed mice could only be evaluated for habitat selection in 2002, because only one mouse was captured in live traps in 2003. White-footed mice selected for trap stations having higher percent cover of shrubs and poison ivy in 2002. The selection for poison ivy sites suggested these mice favored the moister riparian habitats associated with the Bighorn River bottom. The selection for shrubs in 2002 was interesting given that deer mice significantly avoided shrubs at these same live trap transects in 2002. This could suggest a negative association or avoidance between these two species. These mice also appeared to favor trap stations with less bare ground in 2002 at the same time that deer mice were selecting for bare ground, but this avoidance of bare ground by white-footed mice was not significant in the regression model. Similar to deer mice, white-footed mice seemed to avoid trap stations with higher cover of exotic grasses, but again this was not significant.

Although this effort undoubtedly did not achieve a 90% census of LBB, it has greatly expanded the small mammal species list for this park by adding 11 new species of small mammals and achieving at a minimum a 40% census if prior occurrences are included. We also added 3 new species to the known list of herpetofauna for the park. These data provide a good start on the small mammal inventory for this park and also provide some baseline information from a monitoring perspective. Given the protected nature of the park and general lack of human access to much of the park, arguably the most significant ecological change taking place on LBB is that associated with the invasion of exotic plants, particularly cheatgrass, though other exotics were also observed. This study provides some information to suggest that exotic plant invasions may negatively impact the numerically dominant and most generalist species within the park, the deer mouse. Given the adaptive nature of this generalist species, this suggests other small mammals may also be affected, some of which may be quite rare.

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Table 1. Small mammals occurring or potentially occurring on Little Bighorn Battlefield National Monument based on surveys and county records. The species list itself represents possible species as determined from distribution and habitat information (Foresman 2001a). The prior column shows species listed for the park as present or possibly present prior to this survey (NPS database). The current column indicates species trapped or observed in the current survey.

Order	Common name	Scientific name	Prior	Current
Insectivora				
	Cinereus shrew	*Sorex cinereus*		
	Hayden's shrew	*Sorex haydeni*		
	Pygmy shrew	*Sorex hoyi*		
	Merriam's shrew	*Sorex merriami*		X
	Montane shrew	*Sorex monticolus*		
	Dwarf shrew	*Sorex nanus*		
	Water shrew	*Sorex palustris*		
	Preble's shrew	*Sorex preblei*		
	Vagrant shrew	*Sorex vagrans*		
Lagomorpha				
	Snowshoe hare	*Lepus americanus*		
	White-tailed jackrabbit	*Lepus townsendii*		
	Desert cottontail	*Sylvilagus audubonii*		
	Mountain cottontail	*Sylvilagus nuttallii*	X	X
Rodentia				
	Porcupine	*Erethizon dorsatum*	X	
	Northern pocket gopher	*Thomomys talpoides*		X
	Ord's kangaroo rat	*Dipodomys ordii*		
	Olive-backed pocket mouse	*Perognathus fasciatus*		
	Sagebrush vole	*Lemmiscus curtatus*		
	Long-tailed vole	*Microtus longicaudus*		
	Prairie vole	*Microtus ochrogaster*		X
	Montane vole	*Microtus montanus*		
	Meadow vole	*Microtus pennsylvanicus*		
	Bushy-tailed woodrat	*Neotoma cinerea*		X
	Deer mouse	*Peromyscus maniculatus*		X
	White-footed mouse	*Peromyscus leucopus*		X
	Northern grasshopper mouse	*Onychomys leucogaster*		X
	Western harvest mouse	*Reithrodontomys megalotis*		X
	House mouse	*Mus musculus*		
	Black-tailed prairie dog	*Cynomys ludovicianus*		
	Yellow-bellied marmot	*Marmota flaviventris*		
	Northern flying squirrel	*Glaucomys sabrinus*		
	Eastern fox squirrel	*Sciurus niger*		
	Red squirrel	*Tamiasciurus hudsonicus*	X	
	Columbian ground squirrel	*Spermophilus columbianus*		
	Richardson's ground squirrel	*Spermophilus richardsonii*		
	Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*		X
	Yellow-pine chipmunk	*Tamias amoenus*		X
	Least chipmunk	*Tamias minimus*		
	Uinta chipmunk	*Tamias umbrinus*		
	Meadow jumping mouse	*Zapus hudsonius*		X
	Western jumping mouse	*Zapus princeps*		

Table 2 Total number of individuals captured by species of small mammals at Little Bighorn Battlefield National Monument in 2002 and 2003. Where there were recaptures of live individuals, the total number of captures is indicated in parentheses.

Common Name	Scientific Name	2002	2003
Merriam's shrew	*Sorex merriami*	0	1
Mountain cottontail	*Sylvilagus nuttallii*	1	1
Northern pocket gopher	*Thomomys talpoides*	1	0
Prairie vole	*Microtus ochrogaster*	6	7 (8)
Bushy-tailed woodrat	*Neotoma cinerea*	1	0
Northern grasshopper mouse	*Onychomys leucogaster*	0	7 (8)
White-footed mouse	*Peromyscus leucopus*	97 (102)	10
Deer mouse	*Peromyscus maniculatus*	166 (167)	105 (113)
Western harvest mouse	*Reithrodontomys megalotis*	17	4
Yellow-pine chipmunk	*Tamias amoenus*	4	1
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*	1	3 (4)
Meadow jumping mouse	*Zapus hudsonius*	0	2

Table 3. Visual observations and pitfall captures of non-small mammal species at Little Bighorn Battlefield National Monument 2002-2003.

Common Name	Scientific Name	2002	2003
White-tailed deer	*Odocoileus virginianus*	X	
Mule deer	*Odocoileus hemonius*	X	
Antelope	*Antilocapra americana*	X	
Mountain cottontail	*Sylvaligus nuttalli*	X	
Raccoon	*Procyon lotor*	X	
Coyote	*Canis latrans*	X	
Red fox	*Vulpes vulpes*		X
Tiger salamander	*Ambystoma tigrinum*	X	X
Snapping turtle	*Chelydra serpentina*	X	
Greater short-horned lizard	*Phrynosoma hernandesi*	X	
Eastern racer	*Coluber constictor*	X	X
Western rattlesnake	*Crotalus viridis*	X	X

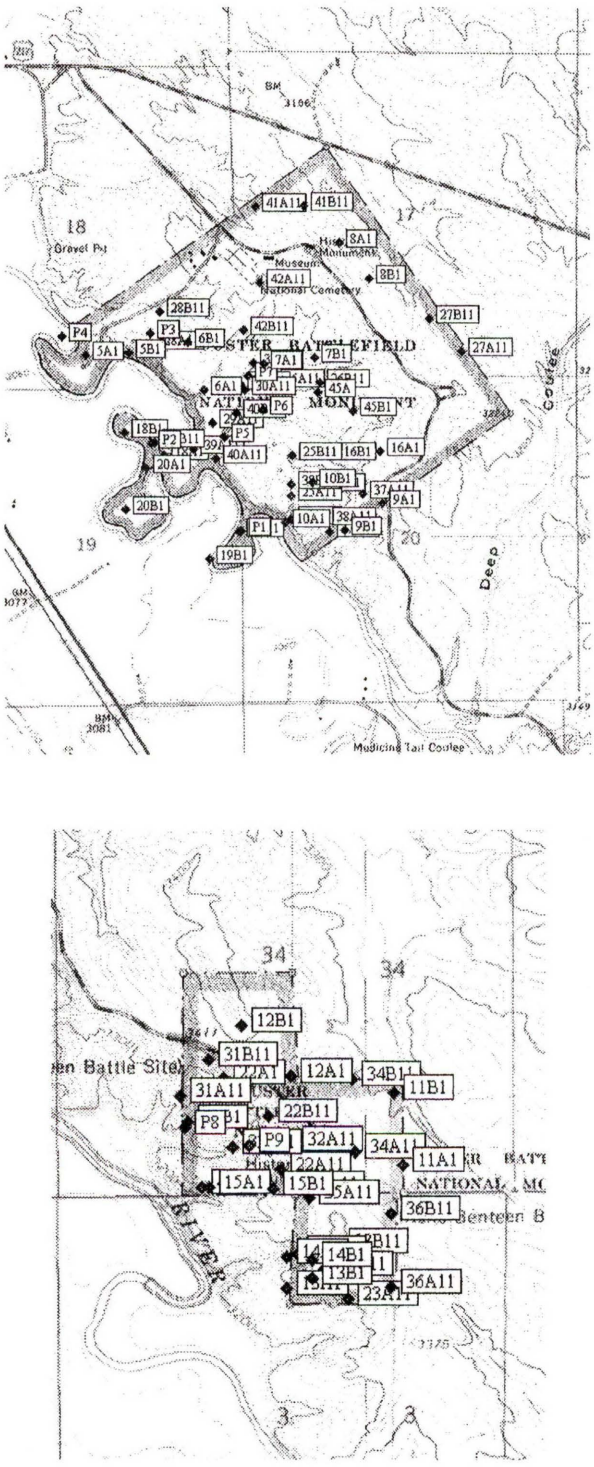

Figure 1. Map showing distribution of trapping effort across Little Bighorn Battlefield National Monument. Top figure is park entrance and main portion of the park. Bottom figure is Reno-Benteen portion of park. Letters and numbers indicate first and last trapping stations for a given transect or trapping site.

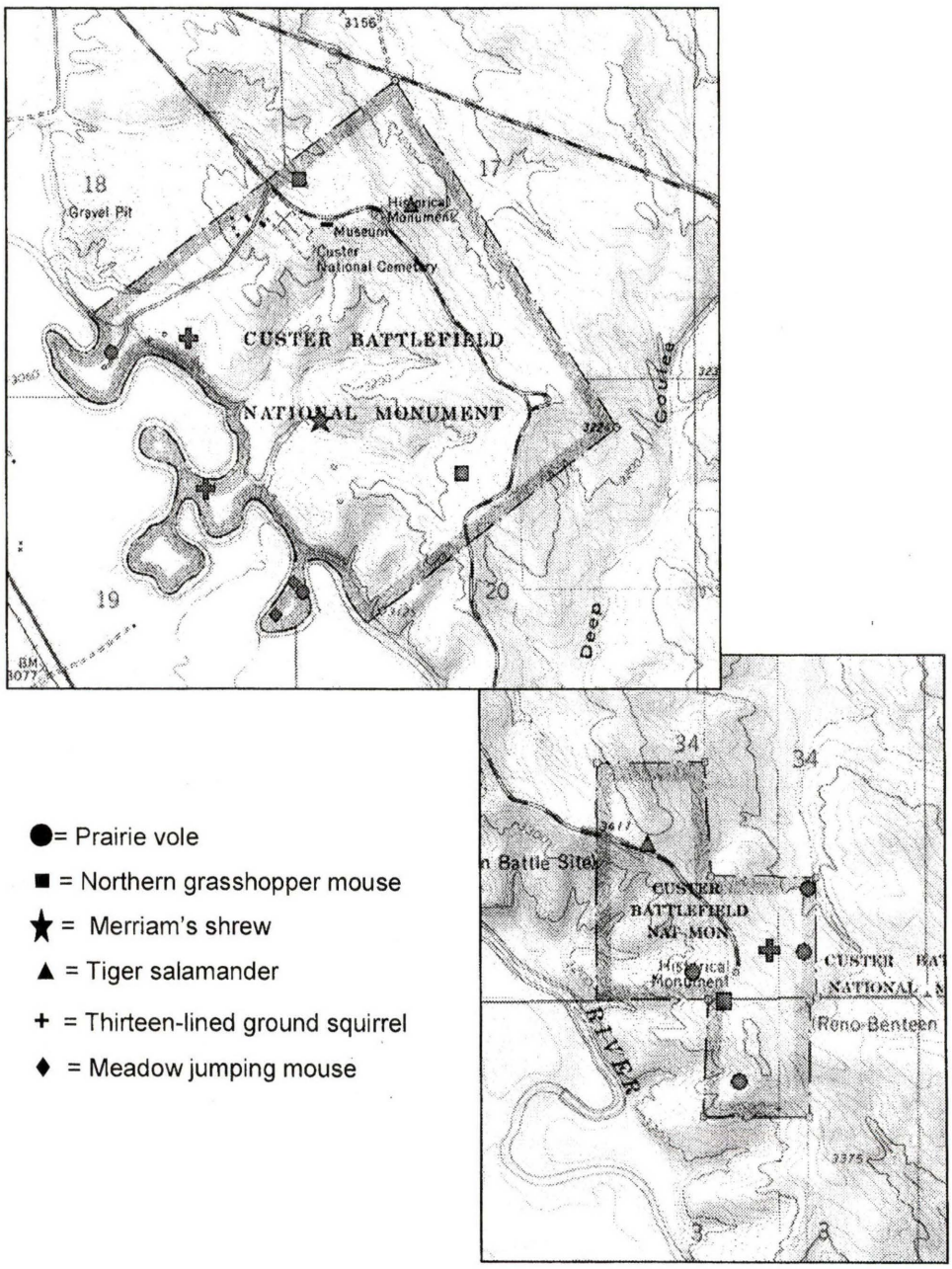

Figure 2. Locations where rare and uncommon species were captured or observed on Little Bighorn Battlefield National Monument from 2002-2003.

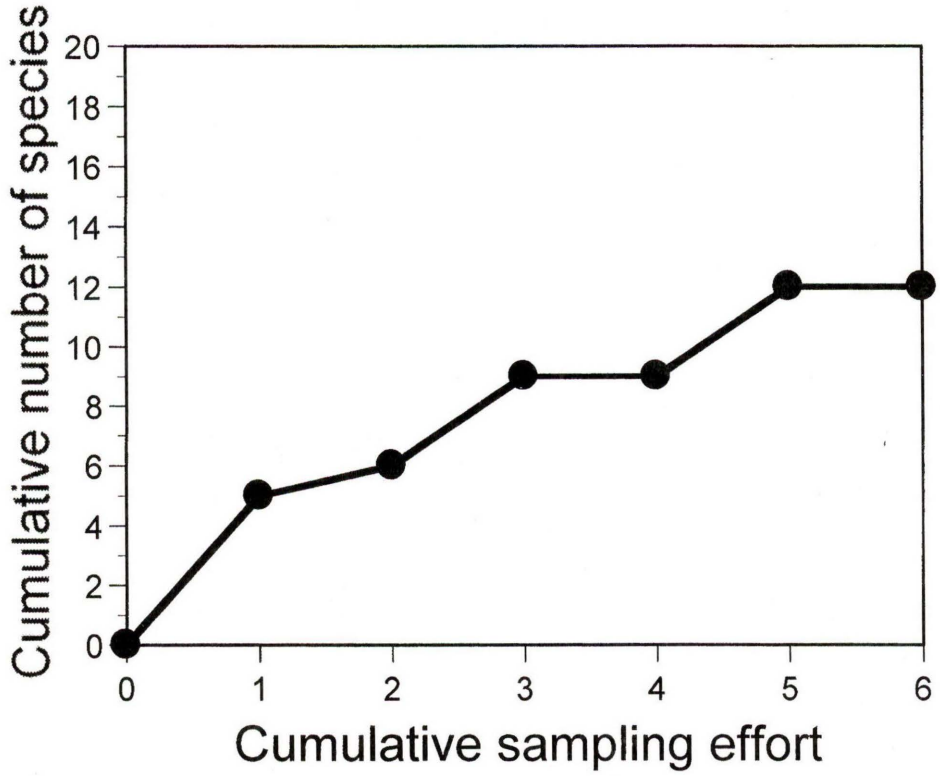

Fig. 3. Species-effort curve showing the cumulative number of small mammal species captured versus cumulative sampling effort. Each sampling period is a week of sampling effort. The first three periods represent the three weeks of sampling in 2002 and the second three represent the three weeks of sampling effort in 2003. Data apply to trapping results only. Visual observations are not included.

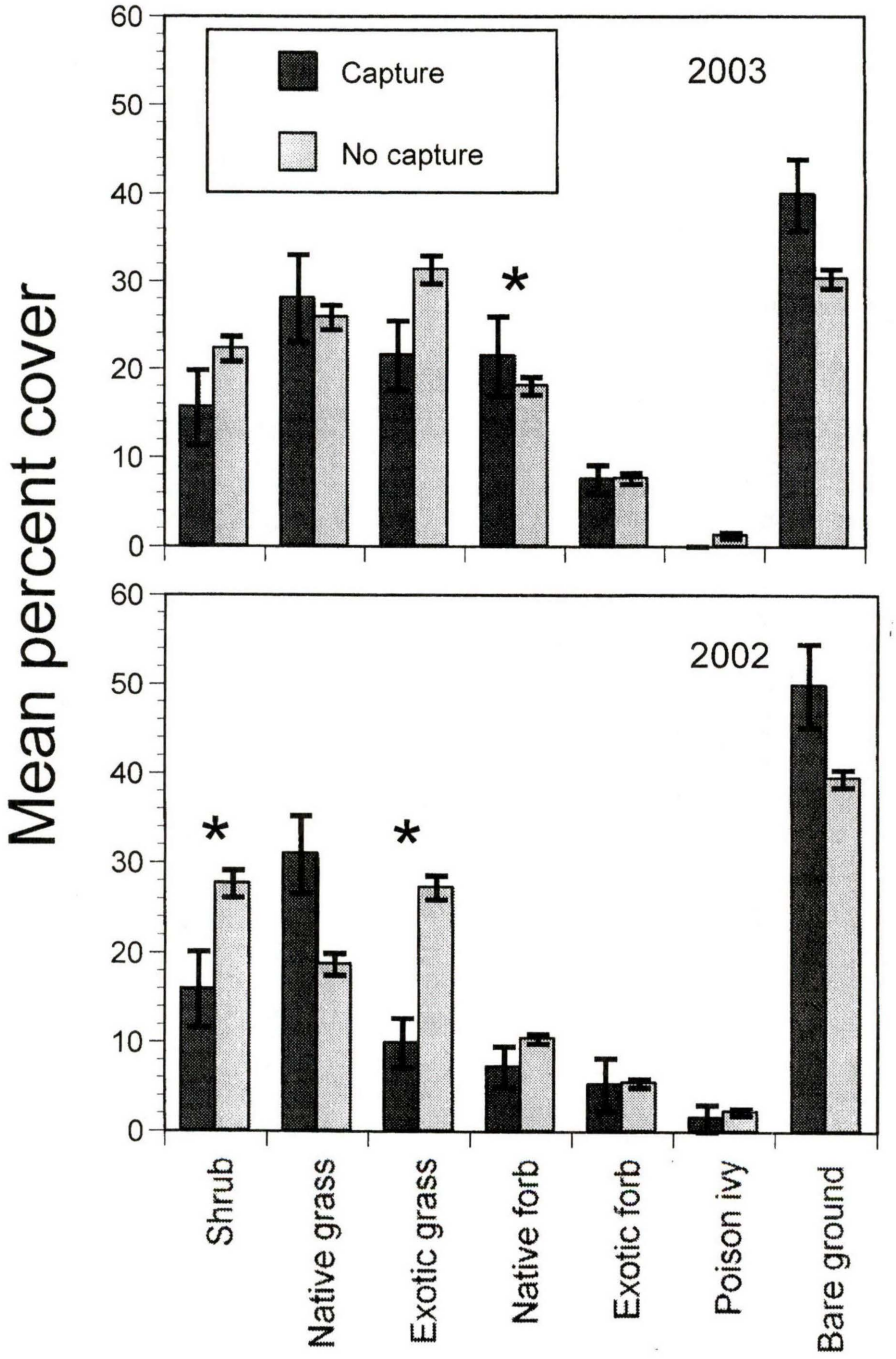

Figure 4. Mean percent cover (±SE) of different habitat variables at live trap stations where deer mice were captured versus stations where deer mice were not captured at Little Bighorn Battlefield National Monument in 2002 and 2003. Asterisks indicate significant variables.

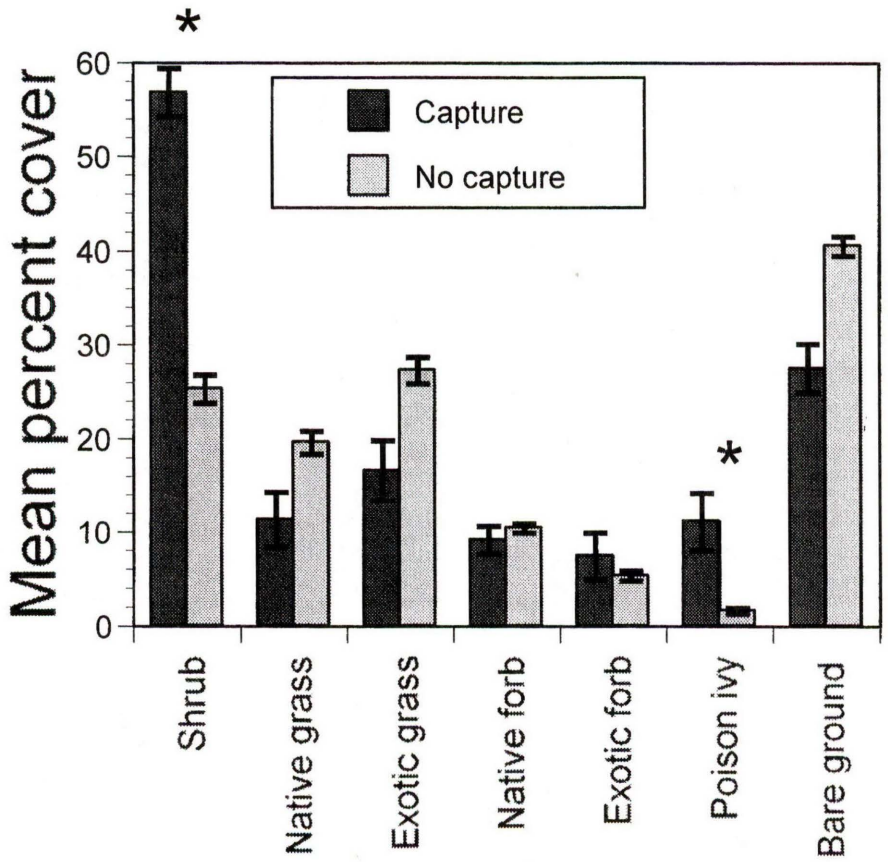

Figure 5. Mean percent cover (±SE) of different habitat variables at live trap stations where white-footed mice were captured versus stations where white-footed mice were not captured at Little Bighorn Battlefield National Monument in 2002. Only one white-footed mouse was captured in live traps in 2003, so these results are not presented. Asterisks indicate significant variables.

Appendix 1. Little Bighorn Battlefield National Monument GPS coordinates and vegetation types at trap locations 2002-2003 (GPS DATUM NAD 27). First trap coordinates correspond with first trap in the transect (A on map) and last trap coordinates with the last trap in the transect (B on map).

		First trap coordinates		Last trap coordinates		
Trans	**Trap Type**	**Easting**	**Northing**	**Easting**	**Northing**	**Dominant Vegetation**
1	LIVE	310193	5048363	310288	5048603	Shrub, Native forb
2	LIVE	310440	5048049	310405	5047887	Bluebunch wheatgrass, Native Forb
3	LIVE	310819	5048482	311002	5048296	Bluebunch Wheatgrass, Native Forb
4	LIVE	309395	5048410	309586	5048442	Shrub
5	SNAP	309500	5048460	309722	5048463	Shrub
6	SNAP	310096	5048267	310179	5048506	Shrub
7	SNAP	310398	5048384	310658	5048414	Shrub, Cheat grass, Bluebunch Wheatgrass
8	SNAP	310796	5048983	310947	5048797	Cheatgrass, Japanese brome
9	SNAP	310977	5047671	310781	5047541	Bluebunch Wheatgrass, Cheatgrass
10	SNAP	310483	5047586	310629	5047788	Cheatgrass
11	SNAP	314653	5043461	314630	5043726	Bluebunch Wheatgrass, Cheatgrass
12	SNAP	314257	5043796	314081	5043987	Bluebunch wheatgrass, Native Forb
13	SNAP	314219	5043022	314311	5043057	Cheatgrass
14	SNAP	314222	5043138	314313	5043123	Cheatgrass
15	SNAP	313949	5043399	314178	5043385	Bluebunch Wheatgrass
16	LIVE	310297	5047780	310635	5047728	Bluebunch Wheatgrass, Native Forb, Salisfy
17	LIVE	310355	5048000	310612	5047887	Bluebunch Wheatgrass, Native Forb, Tumbleweed
18	LIVE	309888	5047943	309712	5048064	Shrub, Native forb, Trees
19	LIVE	310098	5047392	310110	5047392	Shrub, Sedge, Native forb
20	SNAP	309832	5047928	309703	5047733	Shrub
21	SNAP	314046	5043835	313929	5043651	Shrub, Bluebunch Wheatgrass, Cheatgrass
22	SNAP	314264	5043498	314272	5043871	Bluebunch Wheatgrass
23	SNAP	314505	5042981	314520	5043221	Native Forb
24	SNAP	310177	5047869	310406	5047923	Japanese brome, Shrub
26	SNAP	311027	5048293	310770	5048258	Bluebunch Wheatgrass
27	SNAP	311394	5048418	311228	5048603	Bluebunch Wheatgrass
28	SNAP	309801	5048524	309963	5048628	Cheatgrass, Bluebunch Wheatgrass
29	SNAP	310073	5048005	310217	5048190	Cheatgrass
30	SNAP	310315	5048318	310491	5048415	Shrub, Cheatgrass
31	LIVE	313865	5043727	313964	5043881	Bluebunch Wheatgrass, Shrub, Native Forb
32	LIVE	314314	5043552	314091	5043541	Bluebunch Wheatgrass, Shrub, Native Forb
33	LIVE	314246	5043389	314232	5043148	Bluebunch Wheatgrass, Native forb
35	SNAP	314317	5043344	314341	5043111	Bluebunch Wheatgrass, Native Forb
36	SNAP	314615	5042982	314625	5043176	Bluebunch Wheatgrass
37	SNAP	310800	5047770	310669	5047579	Bluebunch Wheatgrass
39	SNAP	310144	5047868	310039	5047959	Cheatgrass, Sage
40	SNAP	310147	5047928	310233	5048125	Cheatgrass, Sage
41	SNAP	310328	5049082	310490	5049111	Bluebunch Wheatgrass, Cheatgrass
42	SNAP	310392	5048792	310393	5048635	Bluebunch Wheatgrass, Needle-and-thread grass
43	SNAP	310954	5048041	310951	5047826	Bluebunch Wheatgrass
44	SNAP	310634	5048133	310855	5048081	Bluebunch Wheatgrass
45	SNAP	310312	5048116	310527	5048027	Bluebunch Wheatgrass, Cactus, Tumbleweed
P1	PITFALL	309425	5048358	N/A	N/A	Sedge, Poison Ivy
P2	PITFALL	309845	5048029	N/A	N/A	Sedge, Native forb
P3	PITFALL	309834	5047898	N/A	N/A	Sedge, Native forb
P4	PITFALL	310260	5047586	N/A	N/A	Shrub, Cheatgrass
P5	PITFALL	310184	5048049	N/A	N/A	Bluebunch Wheatgrass, Cheatgrass, Shrub
P6	PITFALL	310409	5048143	N/A	N/A	Cheatgrass
P7	PITFALL	310308	5048248	N/A	N/A	Bluebunch Wheatgrass, Cheatgrass, Shrub
P8	PITFALL	313895	5043613	N/A	N/A	Cheatgrass, Bluebunch Wheatgrass, Shrub
P9	PITFALL	313925	5043557	N/A	N/A	Bluebunch Wheatgrass, Shrub

Vegetation Key: Bluebunch wheatgrass: *Pseudoroegneria spicata*; Cactus: *Opuntia* spp. Cheatgrass: *Bromus tectorum*; Japanese brome: *Bromus japonicus*; Native forb: Various native forb species; Needle-and-thread grass: *Stipa comata;* Poison ivy:*Toxicodendron radicans;* Salsify:*Tragopogon dubius;* Sage: *Artemesia* sp; Sedge: *Carex* spp.; Shrub: Various species; Tumbleweed: *Sisymbrium* spp.

Appendix 2. Museum specimens from small mammal survey on Little Bighorn Battlefield National Monument.

Species	Animal Number	UTM Coordinates Easting Northing	Year	Age	Sex	Skin	Skull	Total	Tail	Hind Foot	Ear	Wt
SOME	60303	310096 5048267	2003	A	unk	No	Yes	77	33	12	7	4
THAT	4702	313922 5043400	2002	A	unk	No	Yes	191	55	30	6	94
MIOC	50502	309500 5048460	2002	A	M	Yes	Yes	149	31	19	11	39
MIOC	220802	314207 5043454	2002	A	F	No	Yes	142	31	17	8	30
MIOC	352202	314307 5043348	2002	A	F	No	Yes	145	31	19	11	44
MIOC	101103	310483 5047586	2003	A	F	No	Yes	115	19	19	13	25
NECI	479902	313922 5043400	2002	A	unk	Yes	Yes	331	148	33	31	214
ONLE	350603	314317 5043344	2003	A	M	No	Yes	123	34	19	17	21
ONLE	179903	309887 5047944	2003	A	M	Yes	Yes	120	37	19	17	23
REME	111902	314630 5043726	2002	S	F	Yes	Yes	124	56	12	9	10
REME	450202	310669 5048240	2002	A	M	No	Yes	134	61	15	10	10
REME	351303	314341 5043111	2003	A	F	No	Yes	135	65	17	18	11
REME	80403	310796 5048983	2003	A	M	Yes	Yes	133	60	17	14	11
REME	111603	314653 5043461	2003	A	M	Yes	Yes	127	61	16	14	18
REME	241803	310406 5047923	2003	J	M	No	Yes	123	57	18	13	9
SPTR	281002	309844 5048501	2002	A	F	No	Yes	unk	unk	unk	unk	88
TAAM	280102	309844 5048501	2002	A	F	Yes	Yes	206	90	31	14	42
ZAHU	002	310260 5047551	2002	A	F	Yes	Yes	182	118	28	9	14
PELE	201502	309789 5047883	2002	A	M	Yes	Yes	175	74	19	17	25
PEMA	352502	314341 5043111	2002	A	F	Yes	Yes	146	59	20	17	17

SOME = *Sorex merriami* , THAT = *Thomomys talpoides*, MIOC = *Microtus ochrogaster*, NECI = *Neotoma cinerea*, ONLE = *Onychomys leucogaster*, REME = *Reithrodontomys megalotis*, SPTR = *Spermophilus tridecemlineatus*, TAAM = *Tamias amoenus*, ZAHU = *Zapus hudsonius* , PELE = *Peromyscus leucopus*, PEMA = *Peromyscus maniculatus*